PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H01Q 1/24, 11/08, 1/36	A2	(11) International Publication Number: WO 99/17398 (43) International Publication Date: 8 April 1999 (08.04.99)

(21) International Application Number: PCT/US98/20304

(22) International Filing Date: 29 September 1998 (29.09.98)

(30) Priority Data:
08/939,821 29 September 1997 (29.09.97) US

(71) Applicant: ERICSSON, INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

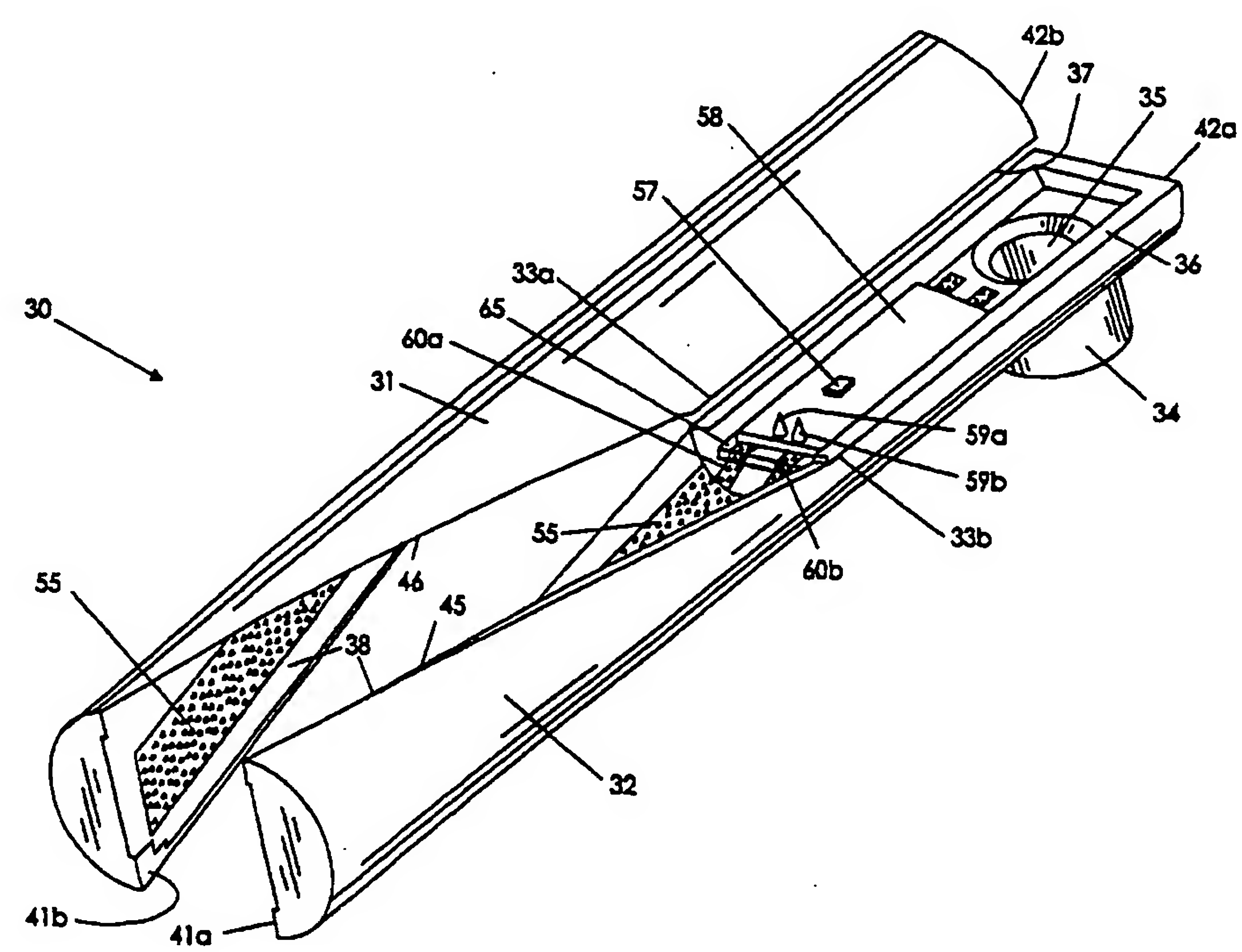
(72) Inventor: RUDISILL, Charles, A.; 3908 Bamburgh Lane, Apex, NC 27502 (US).

(74) Agents: RICHARDSON, Julie, H. et al.; Myers, Bigel, Sibley, & Sajovec, P.A., P.O. Box 37428, Raleigh, NC 27627 (US).

(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: ANTENNAS WITH INTEGRATED WINDINGS



(57) Abstract

Radiotelephone antennas include rigid antenna elements integral to the antenna substrate or housing. As such, the present invention configures the antenna without requiring a separate flex circuit winding to provide the conductive windings in the antenna. Methods for fabrication of the antenna are also described. Preferably, the antenna is formed in a two-shot molding process.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

ANTENNAS WITH INTEGRATED WINDINGS

Field of the Invention

The present invention relates to telephones, and more particularly relates to antennas in telephones.

Background of the Invention

Many telephones employ antennas which are electrically connected to a signal processor housed in the telephone. Various design parameters of the antenna can affect the performance of the radiotelephone. For example, the size and shape of the antenna as well as the way in which the electrical traces of the antenna are interconnected with associated circuitry can impact the performance of the radiotelephone. Additionally, many of the radiotelephones are undergoing miniaturization which can complicate and impose design restraints on the antenna. For example, this miniaturization can create complex mechanical and electrical connections with other components such as the outwardly extending antenna which must generally interconnect with the housing for mechanical support, and, to the signal processor and other internal circuitry operably associated with the printed circuit board in the radiotelephone body.

In the past, portable satellite radiotelephones have employed top loaded monopole antennas, helix antennas, and multiple winding antennas to help improve signal quality. One example of such an effort is a quadrafillar helix antenna which utilizes four spaced-apart filament elements which are wound around an antenna's surface. Preferably, the filament elements are equally spaced around the circumference of the antenna. Typically, these type of elements or windings are printed on a flat material such as a flex circuit material, cut into the appropriate pattern, and then rolled to form the antenna elements. Generally stated, the seams are

then joined with adhesive or tape, and circuit components are attached to one end of the wrapped antenna elements to electrically interconnect the signal processing circuit in the radiotelephone. For example, as illustrated in **Figure 1**, a polyimide film **15** with conductive elements **15a** thereon is rolled to form a helix. Tape **16** is used to bond the seams. End caps **17a, 17b** are positioned over opposing ends of the rolled film **18**. A printed circuit board **19** and coaxial connectors **20** are positioned adjacent the lower end cap **17b**. The connector's **20** associated wires **20a** are routed into the radiotelephone (not shown) through the radome **21** which is positioned over the above-described components.

Unfortunately, fabrication of these flexible antenna elements are typically relatively fragile and can be labor intensive. Further, the positional tolerances of the elements relative to both the antenna cover or "radome" and the roll can be difficult to control. Positional and form variance and the seam construction of the flex windings can undesirably affect the performance of the antenna. Further, attaching the electrical components to the flex circuit material can stress the attachment joint(s) and can require strain-relief designs to attempt to protect the function, durability, and reliability of the antenna.

Objects and Summary of the Invention

It is therefore a first object of the present invention to provide an improved method for fabricating an antenna with conductive windings.

It is another object of the present invention to provide an improved multi-winding antenna.

It is yet another object of the present invention to provide a reliable, durable, and economical satellite antenna for a radiotelephone.

It is a further object of the present invention to provide an improved antenna which can be conveniently adapted for use with existing radiotelephone models.

These and other objects are satisfied by the present invention which includes an antenna with integrated windings formed thereon. A first aspect of the invention is a radiotelephone antenna which comprises a longitudinally extending first member having at least one rigid conductive winding arranged in a first pattern thereon. The antenna also includes a longitudinally extending second member having at least one

rigid conductive winding arranged in a second pattern thereon. The second member is configured to mate and engage with the first member to define an enclosed passage therebetween. When the first and second members are engaged, the first and second pattern of conductive windings are electrically connected and geometrically aligned in a pattern so as to define a signal path. Preferably, the first and second patterns radially translate along the length of the antenna in a helical pattern.

Advantageously, the antenna elements are formed directly onto the antenna housing. Thus, using integral rigid antenna elements can reduce assembly time and labor costs and can reduce manufacturing build variability and improve durability.

In a second embodiment, the antenna comprises a cylindrical non-conductive antenna substrate with first and second opposing ends defining a central axis therethrough. The antenna also includes a plurality of rigid conductive circuit windings integral to the antenna substrate, each of the plurality of conductive circuit windings spaced-apart from each other. Each of the windings are electrically and physically separated from the others, and the circuit windings extend along at least a portion of the length of the antenna housing to define a signal path. Preferably, each of the conductive windings begin at a first radial position on the antenna housing relative to the central axis and translate to a second radial position different from the first radial position along the length of the signal path. Also preferably, each of the conductive windings translate about a surface of the antenna to define a helix pattern along the length of the signal path. An outside housing cover can enclose the substrate, as desired.

An additional embodiment of the present invention is a multi-layer cylindrical antenna. The multi-layer antenna comprises a first core insert layer and a second layer disposed over the first layer. The antenna also includes a third layer disposed over predetermined portions of the second layer opposite the first layer such that the third layer is non-conductive. A conductive fourth layer is disposed over the portions of the second layer remaining uncovered by the third layer. The fourth layer defines at least one signal trace and is arranged with the second and third layers such that each of the at least one signal trace is spaced-apart by the non-conductive third layer. Preferably, the antenna includes four traces arranged in a helical pattern along a major portion of the length of the antenna.

Another aspect of the present invention is a method of fabricating an antenna with integral traces formed thereon. The method includes molding a first antenna layer of a first material having an affinity for conductive coatings in a predetermined geometrical shape. A second antenna layer of a second material is formed over selected areas of the first layer. Surfaces of predetermined portions of the first antenna layer are maintained to be exposed. The exposed surfaces of the first layer is coated with a conductive coating thereby fabricating an integrated conductive signal path antenna. Preferably, the second layer is formed of a non-catalyzed material and the first layer is formed of a catalyzed material. Alternatively, the first layer is formed of a material receptive to metallic coatings and said second material is non-receptive to metallic coatings. In one embodiment, a selected surface of the antenna is exposed to photo-imaging to form a portion of the signal path.

Advantageously, molding the antenna traces integral to the antenna housing or substrate can improve the performance of the radiotelephone as well as reduce labor costs and decrease dimensional variability typically associated with conventional flex circuit fabrication methods.

The foregoing and other objects and aspects of the present invention are explained in detail in the specification set forth below.

Brief Description of the Drawings

Figure 1 is an exploded view of a conventional wrapped antenna and associated separate printed circuit board.

Figure 2A is an enlarged perspective view of one embodiment of an antenna according to the present invention.

Figure 2B is an enlarged exploded perspective view of the antenna of **Figure 2A**, illustrating the assembly of the matable antenna members according to one embodiment of the present invention.

Figure 3 is an enlarged partial perspective view of an antenna with integral circuit windings of the antenna of **Figures 2A and 2B**.

Figure 4 is an enlarged perspective view of an alternative embodiment of an antenna according to the present invention.

Figure 5A is an enlarged perspective view of an additional embodiment of an antenna according to the present invention.

Figure 5B is a side view of an antenna according to the present invention illustrating an alternative winding configuration.

Figure 5C is a side view of an antenna according to the present invention illustrating yet another alternative winding configuration.

Figure 5D is an enlarged perspective view of another embodiment of an antenna according to the present invention.

Figure 6 is an enlarged partial cutaway view of yet another embodiment of an antenna according to the present invention.

Figure 6A is a sectional view of the antenna of **Figure 6**.

Figure 7A is a perspective view of a first stage molding process illustrating predetermined raised surfaces on an antenna sub-component according to one aspect of the present invention, the raised surfaces will be conductive in a finished part as shown in **Figure 7C**.

Figure 7B is a perspective view of a second stage of a molding process illustrating the molded part of **Figure 7A** with additional material molded over predetermined areas of the first sub-component.

Figure 7C is a sectional view of the part illustrated in **Figure 7B** after the part has been metallically plated according to one embodiment of the present invention.

Figure 8A is a partial section view of an antenna body undergoing photo-imaging to provide rigid traces on a substrate according to one embodiment of the present invention.

Figure 8B is a partial section view of the antenna body shown in **Figure 8A** after the photo-resist material has been exposed and developed.

Figure 8C is a partial section view of the rigid traces formed on the antenna body shown in **Figure 8B** after the photo-resist material and copper background has been removed.

Description of Preferred Embodiments

The present invention will now be described more fully hereinafter with reference to the accompanying figures, in which preferred embodiments of the

invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Like numbers refer to like elements throughout. Layers may be exaggerated for clarity. As used herein, rigid is meant to include windings or traces which are sufficiently inflexible such that they are static, *i.e.*, such that they are fixed along an expanse of the (antenna) body.

The present invention is directed towards antennas and is especially advantageous for antennas used in portable radiotelephone applications. Generally described, the present invention integrally forms the antenna element(s) directly into the antenna housing. This advantageously eliminates the wrapping or forming and assembly procedures of conventional flex circuit wrapped antennas as described above by providing rigid antenna elements integral to the housing or antenna substrate. Turning now to the figures, **Figure 2A** illustrates an antenna 30 of one embodiment of the instant invention. As shown in **Figure 2A**, the antenna 30 includes longitudinally extending first and second members **31, 32** which are matably sized and configured to assemble together. Preferably, as shown in **Figure 2B**, when the members **31, 32** are assembled together, they define an enclosed passage therebetween. Also preferably, the members **31, 32** include opposing first and second ends **41a, 41b** and **42a, 42b**. Thus, when assembled, the members align to form closed ends thereby protecting the enclosed components from environmental conditions.

Further, in a preferred embodiment, as illustrated in **Figures 2A** and **2B**, the first and second members **31, 32** include laterally extending portions **33a, 33b** which mate with the other and form a cylinder when assembled together. Of course, alternative shapes or configurations can also be used such as oval, square, and the like. Preferably, a symmetrical shape is employed and most preferably a cylindrical shape. The laterally extending portions **33a, 33b** can be further described as having opposing first planar portions **36, 37** and opposing second portions **45, 46** each of which are angled with respect to the corresponding first portions **36, 37**. Advantageously, as will be discussed in more detail below, this configuration allows a mold or parting line to be positioned between conductive traces **55** and can help assure minimal electrical mismatch in the signal path. The two members **31, 32** can

be assembled together in any number of ways as is well known to those of skill in the art. For example, the parts can be joined by press fit, ultrasonic weld, or bonded or joined with adhesive. If desired, crossovers at the top of the antenna **30** can be provided with additional traces, interlocking tabs, or an additional component installed into the interior of the members **31, 32** prior to assembly for electrically connecting traces crossing over the surface of the antenna (not shown).

The antenna **30** can be mechanically attached to a radiotelephone (not shown) by a pivot or hinge **34**. Of course, as is well known by those of skill in the art, any number of additional attachment means can be employed such as adhesive, bonding, screw, quick connects, and the like. Preferably, a pivotable attachment means is used so that the antenna **30** may be rotated to an extended position for use and then rotated back to a stowed position to rest against the radiotelephone body when not in use (not shown). As shown in **Figures 2A, 2B**, and **3**, the pivot **34** includes an opening **35** through which electrical connections with the radiotelephone can be maintained. For example, as will be appreciated by those of skill in the art, electrical connections such as wires can be routed through the opening **35** and into the receiving member of the pivot. Alternatively, the external surface of the pivot can provide circuit connections (not shown).

As shown in **Figure 2A**, the antenna **30** includes a non-conductive (cylindrical) housing **56** and at least one integral and structurally rigid conductive circuit trace or antenna element **55**. The housing can comprise one, two, or more members, but in this embodiment preferably includes two members as discussed above. **Figures 2B** and **3** illustrate the internal portion of a preferred embodiment of one of the members **32** which forms half of the antenna. As shown in **Figure 3**, the first member **32** includes two traces **55a, 55b** integral to the housing, *i.e.*, formed directly on the inner radius of the housing member. Similarly, the opposing member **31** also includes two traces **55c, 55d** (not shown) to provide a quadrafillar antenna. Also as shown, the windings **55a, 55b** are spaced-apart and separated by or interposed with non-conductive housing material **56**. Upon assembly, the windings or traces **55** are electrically connected to geometrically align and complete a signal path. Thus, each of the first member and second member **31, 32** includes a predetermined trace **55** pattern which, upon assembly together, electrically engage to define a signal path.

As shown in **Figures 2B** and **3**, the antenna **30** also includes an auxiliary printed circuit board **58** mounted to a rigid support portion **65** of the housing. In particular, the auxiliary circuit board **58** is preferably positioned in the planar portion **36** of the antenna housing member **32** intermediate of the pivot **34** and the angular portion of the member **32** to facilitate connection with the signal processor in the radiotelephone (not shown) to allow electrical transmission of the signal or RF feed from and to the antenna. Of course, as will be understood by one of skill in the art, alternative circuit board connections and configurations can also be used to interconnect the traces or windings **55a, 55b** to the desired circuitry associated with the telephone or device.

As shown in **Figure 3**, the printed circuit board **58** includes various circuitry **57** and electrical contacts for connection with the individual traces **55**. As shown, two of the electrical contacts **59a, 59b** are protruding contacts which laterally extend towards the opposing member **31** for interconnection of antenna elements **55c, 55d** contained on the opposing mating portion of the antenna housing **31**. Also as shown, traces **55a, 55b** on the member **32** are electrically connected to the auxiliary printed circuit board **58** via conductive strips **60a, 60b** formed in the housing from each of the windings to the board. Thus, all four traces are connected to the printed circuit board **58**. Alternative configurations or electrical interconnections of the rigid traces of the antenna to the respective printed circuit board contact include, but are not limited to, soldering, press-fit pins, elastomeric connectors and the like.

Figure 4 illustrates an additional embodiment of an antenna **30'** according to the instant invention. Unlike the embodiment discussed above, this embodiment includes a unitary substrate **131** and the rigid antenna elements or traces **55** are formed on the circumference of the antenna **30'**. The traces can be either recessed or substantially flush with the adjacent non-conductive housing material, or raised to laterally extend beyond the non-conductive surfaces **56**. As shown, the antenna **30'** includes a pivot **34'** and integrally formed cable retention or cable routing channels **150a, 150b**. Preferably, as shown, the antenna **30'** also includes integrally formed and outwardly accessible electrical traces **160** disposed between the auxiliary circuit board **58** and the end **142** of the antenna to electrically connect the signal path(s) from the antenna with the telephone. Generally stated, radiotelephones include two signal

paths, one for satellite and one for cellular communication. As such, as shown in **Figure 4**, the traces **160** include a first signal trace **161**, a ground trace **163**, and a second signal trace **162**. Correspondingly, the traces are preferably sized and configured with cable routing channels **150a**, **150b** to receive respective signal coaxial cables therein.

The antenna substrate **131** can be a solid but preferably lightweight body (such as a cylinder or other configuration). Alternatively, as illustrated in **Figure 5A**, the antenna **30'** can be configured with a hollow core **175**. Each of these alternatives will preferably provide a light weight antenna body to facilitate easy transportability and use. **Figures 5B** and **5C** illustrate additional trace **55** patterns as will be discussed further below.

Figures 6 and **6A** illustrate an additional embodiment of an antenna **30'** with a hollow core **175**. This configuration includes a hollow insert **275**, shown as a cylindrical insert **275**. The insert **275** is positioned internal to the substrate member **131** to keep the core open during fabrication of the substrate and becomes part of the antenna structure as will be discussed further below. Preferably, the insert **275** is a closed end hollow cylindrical insert, allowing the end cap to be integral to the antenna housing body **131**. Advantageously, this configuration allows a trace **55** to be integrally positioned in the end cap **141** concurrently with the traces **55** in the antenna body **131**. In a preferred embodiment, the housing **131**, the closed end cap **141**, and the windings or traces **55** thus provide a unitary integral body. A crossover **151** with an electrical trace **151a** can also be positioned in the end cap **141** to provide an electrical path over the trace **55** crossing thereunder. Alternatively, a low density core insert can be employed such that it fills the core volume but is light weight and yet able to maintain the structural integrity of the substrate during fabrication of same (not shown). Yet an additional alternative is to form the fabrication tooling to be removable after the housing is formed so that the core is hollow, as will also be discussed further below.

As illustrated by the sectional view of **Figure 6A**, one preferred embodiment of a hollow core antenna **30** includes four layers. The first layer **180** is the insert **275** which includes a hollow core **175**. The second layer **280** overlays and is molded to the first layer **180** and is preferably a platable polymer. The third layer **380** overlays

and is preferably molded and the like to predetermined portions of the second layer **280.** The third layer **380** is non-conductive and is the portion of the antenna structure **56** which forms the housing **131** and separates the conductive traces **55**. The fourth layer **480** overlays portions of the second layer **280** not covered by the third layer **380** and is plated or similarly treated to be conductive to provide the conductive traces **55**. Preferably, as shown in **Figure 6A**, the traces **55** (defined by the fourth layer **480**) extend radially outward a distance greater than the adjacent third layer **380**. Also preferably, the second layer **280** extends through the perimeter of the third layer **380** in four separate radial positions to provide a quadrafillar trace pattern. Although not shown, a fifth layer of a thin coating, film or the like, can also be positioned over any externally exposed traces to protect them from environmental conditions.

Referring now to the winding or trace pattern, it is preferred that multiple traces **55** be geometrically aligned and configured along a portion of the antenna **30** such that they form a signal path on the antenna. The traces **55** more preferably extend along a major portion of the length of the antenna (greater than half the length). The longitudinally extending antenna **30** can be described as defining a central axis through the center thereof. As such as shown in **Figure 5A**, in a preferred embodiment, each of the conductive windings or traces **55** begin at a first position **99a** on the antenna housing relative to the central axis and translate to a second radial position **99b** different from the first radial position along the length of the signal path. The radial translation can be any number of radians to provide a desired signal path, such as 15 degrees, 30 –90 degrees, or more. For larger radial translations, a serpentine pattern may be advantageous to employ so as to efficiently fit multiple windings on the circumference of the antenna. Of course numerous other geometric configurations are also suitable, and the instant invention is not limited to the helical or sinusoidal pattern exemplary described herein. It is further preferred that four spaced-apart traces **55** be configured along a portion of the antenna **30**. As illustrated in **Figures 5A** and **6A**, it is most preferred that the traces **55** be arranged in a quadrafillar helix pattern.

Preferably, the electrical length of the antenna **30, 30'** (typically defined by the length and configuration of the traces) is predetermined. Further preferably, the electrical length of the antenna **30, 30'** is configured to provide a quarter or half

wavelength so that the antenna 30, 10' resonates with the operation frequency (typically about 1500-1600 MHz).

Turning now to **Figures 7A, 7B, and 7C**, a preferred method of fabricating an antenna is illustrated. In this embodiment, a two-shot molding process is used to form the configuration of the antenna 30. Two different materials or material compositions are preferably used, one with an affinity for conductive coatings **480** (which will form the base of the conductive traces **55**) and one without such affinity **580** (which will form the non conductive housing **56** intermediate the traces **55**). The first material **480** is used in the first shot and the second material **580** in the second shot. Examples of first and second materials which can be used include materials with and without catalysts, or materials which are platable and a non-platable material; for example, liquid crystal polymer, ULTEM, and aromatic nylon.

Preferably, in the first shot (**Figure 7A**), a catalyzed polymer material is molded in a manner which exposes predetermined portions or surfaces desired to be conductive in the end component for plating or other metallic or conductive coatings after the second mold shot is disposed onto the first mold shot. For example, as illustrated in **Figure 7A**, the first shot forms the layer **280** over the core and provides material which will interrupt the third layer **380** so that it is non-contiguous along the trace length along with respect to a surface of the antenna. In the second shot (**Figure 7B**), the second material such as an uncatalyzed polymer is molded over predetermined portions or surfaces of the first material to insulate areas in which conduction is not desired, and in a manner which leaves the catalyzed polymer of the first material exposed on surfaces where plating is desired. Referring again to **Figure 7A**, the second material such as a non-platable polymer forms layer **380** and non-conductive housing areas **56**. After molding, the exposed surfaces of the first material can be plated or coated or otherwise treated (**Figure 7C**), to create the conductive and non-conductive pattern desired to define the separate signal and ground paths thereon. As shown in **Figure 7A**, the fourth layer **480** is formed by metallizing the platable polymer or first material thus providing the integral traces **55**. Many ways exist to implement the conductive coating, such as dipping, plating, or painting the desired surface treatment thereon. Preferably, plating is used to obtain the conductive surface. In a preferred embodiment, an electroless plating deposit is placed on the

exposed catalyzed features. Typical electroless and electroplated materials include copper nickel, tin, and gold.

Alternatively, one may employ a photo-imaging and photoresist technique by using multiple exposures to form the desired electrical pattern or structure. Of course, combinations of photo-imaging and the two-shot molding process can also be used. For example, circuits that wrap around edges may be formed using the two-shot process, while the crossover pattern on the end cap 141 can be added using photo-imaging.

Figures 8A, 8B, and **8C** illustrate one embodiment of an antenna body **30a** having rigid traces **555** formed by a photo-resist process. **Figure 8A** illustrates a first substrate layer **500**. This layer is non-conductive such as a polymer or plastic. This is the base layer and is preferably longitudinally extending similar to those antenna bodies shown in **Figures 4 and 5**. Preferably, the substrate is cylindrically shaped. A thin layer **510** of conductive material is placed on the substrate **500**. This will prepare the base substrate layer **500** for adhesion with other materials in subsequent processing. An example of a suitable material layer for this material layer **510** is a copper flash layer typically disposed via thin electroless copper plating. A photo-resist material **520** is then disposed on the thin conductive layer **510**. Preferably, the photo-resist is negative acting. A formed mask **540** is positioned over the photo-resist layer **520**. The formed mask includes opaque **531** and transparent portions **530** and is configured to overlay the cylindrical substrate such that the traces will be defined by the imaging pattern thereon. Various projection methods of exposure can also be used in lieu of a contact mask. Because a negative acting photo-resist is described, the opaque portions **531** correspond to areas which are desired to form the rigid signal traces **555** on the substrate **500**. A light source **600** is applied to expose or image the desired areas on the substrate **500** through the mask **540** (typically at about 265 nano-meter wavelengths).

After imaging or exposure, the photo-resist material is developed. As shown in **Figure 8B**, the areas blocked by the opaque portion 531 of the mask **540** are further exposed to electroplate conductive materials (Cu, Au, etc...) to add desired conductor thicknesses to the underlying copper layer **510** to provide a second layer **550** of conductive material thereon. As shown in **Figure 8C**, the antenna body **30a** is then

completed by stripping the photo-resist **520** and etching away the background copper material **510** which is positioned between the signal traces **555**. Thus, a multi-layer antenna body **30a** with at least one rigid signal trace is provided. As shown, the antenna body includes a substrate layer **500**, a second layer of conductive material **510**, and a third layer of conductive material **550**. The second and third layers define the signal traces **555** thereon. Preferably, the signal traces are shaped similar to those discussed above in alternative embodiments. As will be appreciated by one of skill in the art, the antenna body **30a** can also include vias formed through the substrate **500**. The negative resist process allows the via to be processed to provide a conductive signal path through the substrate layer **500** and can interconnect or provide signal paths between the layers.

In summary, the instant invention allows the antenna configuration to have integral windings **55** thereon as well as other mounting and interconnection features (electrical and mechanical). For example, molded tabs, press-fit pins, electrical contacts and traces from the helix or windings **55** to the printed circuit board. In addition, if a three-layer or higher circuit board is not necessary, all the circuitry may be placed on the molding itself without the need for a separate auxiliary printed circuit board. Three-layer or greater circuits are not preferred to be formed in the molding process described above because of the costs typically associated therewith.

Although the description has described the antenna with a rigid support portion **65** and integrated pivot **34** formed in the longitudinal body or member, it will be appreciated by those of skill in the art that multiple components can be used to provide same. Similarly, although described throughout as a cylindrical antenna, the antenna can be alternatively shaped. Further, although shown as a contiguous substrate with the windings separated by non-conductive material (such as in **Figure 4**), the rigid antenna windings **55** can be formed or configured such that they are separated by free-space. **Figure 5D** illustrates one possible embodiment of a bird cage antenna winding structure 30'' which can provide a desired rigid winding configuration. For example, a plurality of windings **55** structurally connected at the top and bottom portions **132, 133** but spaced-apart therebetween by free-space or air. This embodiment can reduce the amount of material used (lighter weight) and can even allow both sides of the traces to be conductive.

As described above, it is preferred that the antenna be configured as a hollow core structure. It is preferred that when molding the antenna, tooling is used which will form the molded material into a hollow structure and then which will be removed when the material is cured. When molding a two member antenna as illustrated in **Figures 2 and 3**, the tooling can be easily removed because of the central parting line. However, when molding a one-piece body (**Figures 4, 5,** and **6**) the tooling is removed from one end of the molded body. In such a situation, it is preferred that the antenna be configured slightly larger at one end to allow easier removal of the tooling. Alternatively, as discussed above, a stationary core insert **275** can be employed. Advantageously, this type of insert will provide a hollow core without requiring removal of the insert. The stationary core insert can be a hollow core insert such as a blow molded hollow tube or flow molded thin material, or a low density or foam type insert. The latter type of insert can be subsequently processed such as by acid etch to remove the material from the core.

As will be appreciated by those of skill in the art, the above described aspects of the present invention may be provided by hardware, software, or a combination of the above. For example, one or more components of the circuit **57**, can be a implemented as a programmable controller device or as a separate discrete component. Of course, discrete circuit components and discrete matching or other electrical circuits corresponding to the impedance requirements of the antenna can be employed with the integrated antenna and can be mounted separately or integrated into a printed circuit board. Similarly, the term "printed circuit board" is meant to include any microelectronics packaging substrate.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. In the claims, means-plus-function clause are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Therefore, it is to be understood that the foregoing is

illustrative of the present invention and is not to be construed as limited to the specific embodiments disclosed, and that modifications to the disclosed embodiments, as well as other embodiments, are intended to be included within the scope of the appended claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

THAT WHICH IS CLAIMED IS:

1. A radiotelephone antenna, comprising:

a longitudinally extending first member having at least one rigid conductive winding arranged in a first pattern thereon; and

a longitudinally extending second member having at least one rigid conductive winding arranged in a second pattern thereon, said second member configured to matably engage with said first member to define an enclosed passage therebetween, wherein when said first and second members are engaged, said first and second pattern of conductive windings are electrically connected and geometrically aligned in a pattern to define a signal path.

2. An antenna according to Claim 1, wherein said first and second patterns radially translate along the length of the antenna in a helical pattern.

3. An antenna according to Claim 2, wherein said first member and said second member comprise laterally extending portions which mate with the other when assembled theretogether.

4. An antenna according to Claim 3, wherein said laterally extending portions include a first planar portion and a second portion angled with respect to said first portion, and wherein each of said at least one windings are disposed on said angled portion.

5. An antenna, comprising:

a non-conductive antenna substrate having first and second opposing ends and defining a central axis therethrough; and

a plurality of rigid conductive circuit windings integral to said antenna substrate, each of said plurality of conductive circuit windings spaced-apart from each other, wherein each of said windings are electrically and physically separated from the others, and wherein said circuit windings extend along at least a portion of the length of said antenna substrate to define a signal path.

6. An antenna according to Claim 5, wherein each of said conductive windings begin at a first radial position on said antenna substrate relative to the central axis and translate to a second radial position different from said first radial position along the length of the signal path.

7. An antenna according to Claim 6, wherein each of said conductive windings translate about a surface of said antenna to define a helix pattern along the length of the signal path.

8. An antenna according to Claim 6, wherein said antenna includes matably configured first and second members, and wherein said first member includes a first conductive winding pattern which radially translates along the length of the signal path and said second member includes a second conductive winding pattern which radially translates along the length of the signal path such that when said first and second members are engaged, said first and second winding patterns are electrically engaged to define the signal path.

9. An antenna according to Claim 5, said antenna further comprising a rigid support portion for holding electronic components thereon, said support portion disposed in one end of said antenna and configured to be electrically connected with each of said windings.

10. An antenna according to Claim 9, wherein said support portion includes a pivot joint thereon.

11. An antenna according to Claim 10 in combination with a radiotelephone, wherein said antenna is affixed to said radiotelephone via said pivot joint.

12. An antenna according to Claim 11, said support portion further comprising cable retention guides for locating electronic cables routed from said antenna to said radiotelephone.

13. An antenna according to Claim 6, further comprising a core member internally positioned is said antenna housing to firmly abut the inner diameter of said antenna substrate.

14. An antenna according to Claim 13, wherein said conductive windings are positioned on the outer surface of said substrate.

15. An antenna according to Claim 14, wherein said antenna substrate, said conductive windings, and said core member are co-joined by molding together.

16. An antenna according to Claim 5, wherein said windings are circumferentially positioned along a major portion of the length of said antenna substrate.

17. An antenna according to Claim 5, wherein said windings are internally positioned on the inner diameter along a major portion of said antenna substrate.

18. An antenna according to Claim 14, wherein said antenna substrate further includes a closed end having at least one conductive winding thereon.

19. An antenna according to Claim 18, wherein said antenna substrate, said conductive windings, and said antenna closed end define a unitary integral body.

20. A multi-layer cylindrical antenna comprising:

a first core insert layer;

a second layer disposed over said first layer;

a third layer disposed over predetermined portions of said second layer opposite said first layer, wherein said third layer is non-conductive; and

a conductive fourth layer disposed over the portions of said second layer not covered by said third layer, wherein said fourth layer defines at least one signal trace, and wherein said fourth layer is arranged with said second and third layers such that each of said at least one signal traces is spaced-apart by said non-conductive third layer.

21. A method of fabricating an antenna with integral traces formed thereon, comprising the steps of:

molding a first antenna layer of a first material having an affinity for conductive coatings in a predetermined geometrical shape;

forming a second antenna layer of a second material over selected areas of said first layer;

maintaining exposed surfaces of predetermined portions of said first antenna layer; and

coating exposed surfaces of said first layer with a conductive coating thereby fabricating an integrated conductive signal path antenna.

22. A method according to Claim 21, wherein said second layer is formed of a non-catalyzed material and said first layer is formed of a catalyzed material.

23. A method according to Claim 21, wherein said first layer is formed of a material receptive to metallic coatings and said second material is non-receptive to metallic coatings.

24. A method according to Claim 21, further comprising the step of:

assembling discrete circuit components on said antenna to electrically communicate with said signal path when an antenna is connected to a radiotelephone.

25. A method according to Claim 21, further comprising the step of: exposing a selected surface to photo-imaging to form a portion of said signal path.

26. A method according to Claim 21, further comprising the step of:

positioning a stationary core in a mold, prior to molding the first antenna layer.

27. A method according to Claim 21, wherein said antenna is molded in separate matable components as a first and second member.

28. A method according to Claim 27, wherein a removable core shape is employed to form a hollow antenna passage, and wherein said core shape is removed prior to assembly of the first and second members.

29. An antenna body having rigid traces thereon, said antenna body comprising:

a longitudinally extending substrate having a plurality of rigid conductive windings thereon, wherein each of said plurality of conductive windings are spaced-apart.

30. An antenna body according to Claim 29, wherein said conductive windings are spaced apart by openings in said substrate.

31. An antenna body according to Claim 30, said substrate includes top and bottom portions configured to structurally join said plurality of conductive windings.

32. An antenna body according to Claim 29, wherein each of said plurality of rigid conductive windings are spaced-apart by non-conductive material defined by said substrate.

33. A multi-layer antenna body, comprising:

a longitudinally extending first substrate layer;

a second conductive layer disposed over predetermined portions of said first layer;

a third conductive layer disposed over said second layer, wherein said second and third layers define at least one rigid signal trace integral to said first layer providing a signal path thereon.

34. An antenna body according to Claim 32, wherein said longitudinally extending first substrate layer is cylindrically shaped and extends about a central axis and said second and third layers define a plurality of signal traces, and wherein each of said signal traces begin at a first radial position on said first substrate layer relative to the central axis and translate to a second radial position different from said first radial position along the length of the signal path.

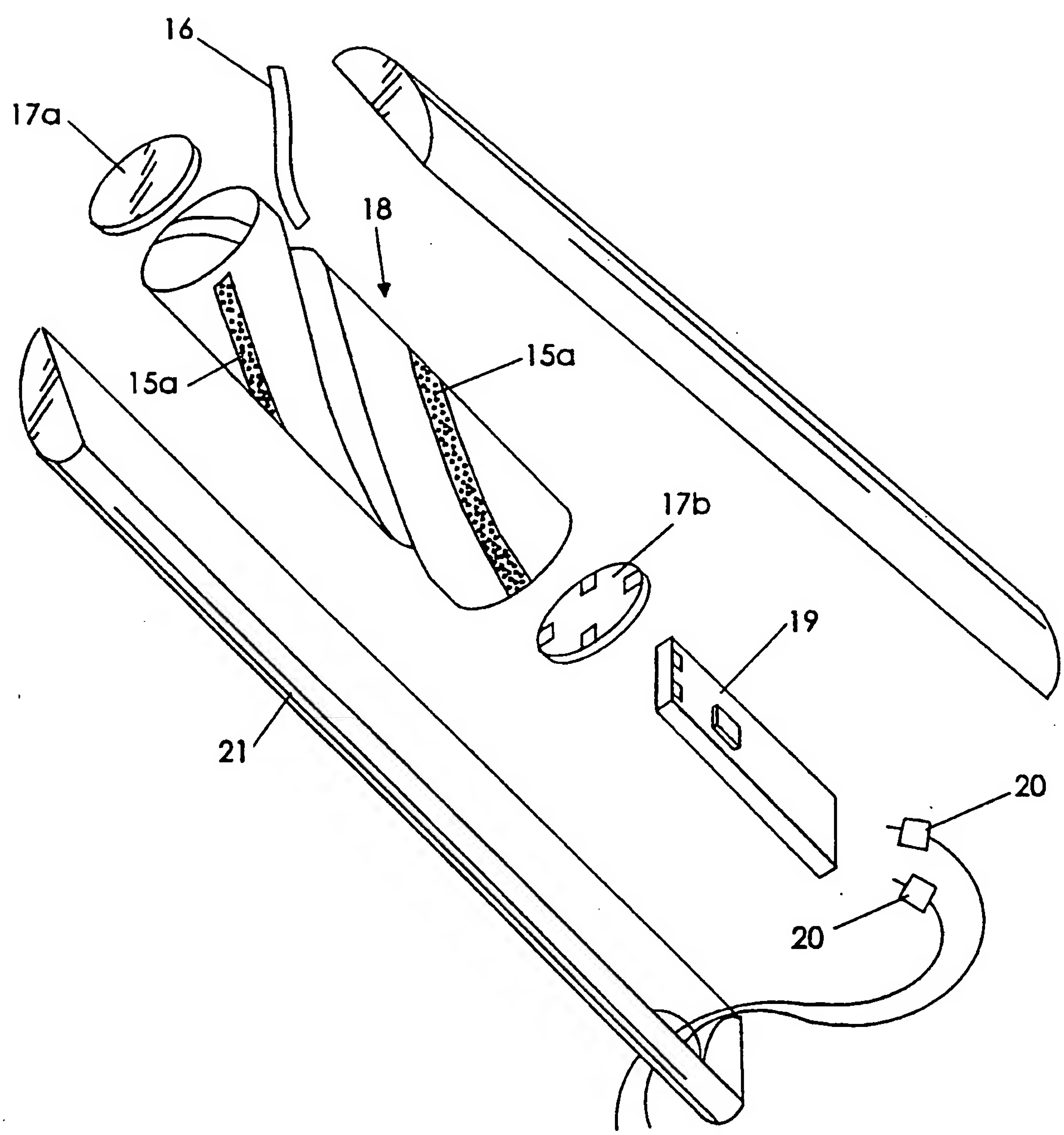
35. An antenna body according to Claim 33, wherein each of said signal traces translate about a surface of said antenna body to define a helix pattern along the length of the signal path.

36. An antenna body according to Claim 33, wherein said signal traces are positioned on the outer surface of said first substrate layer.

37. An antenna body according to Claim 32, wherein said first substrate layer, and said signal traces are formed integral to said substrate by photo-resist imaging.

38. An antenna body according to Claim 32, wherein said at least one trace is circumferentially positioned along a major portion of the length of said first substrate layer.

FIG. 1
PRIOR ART



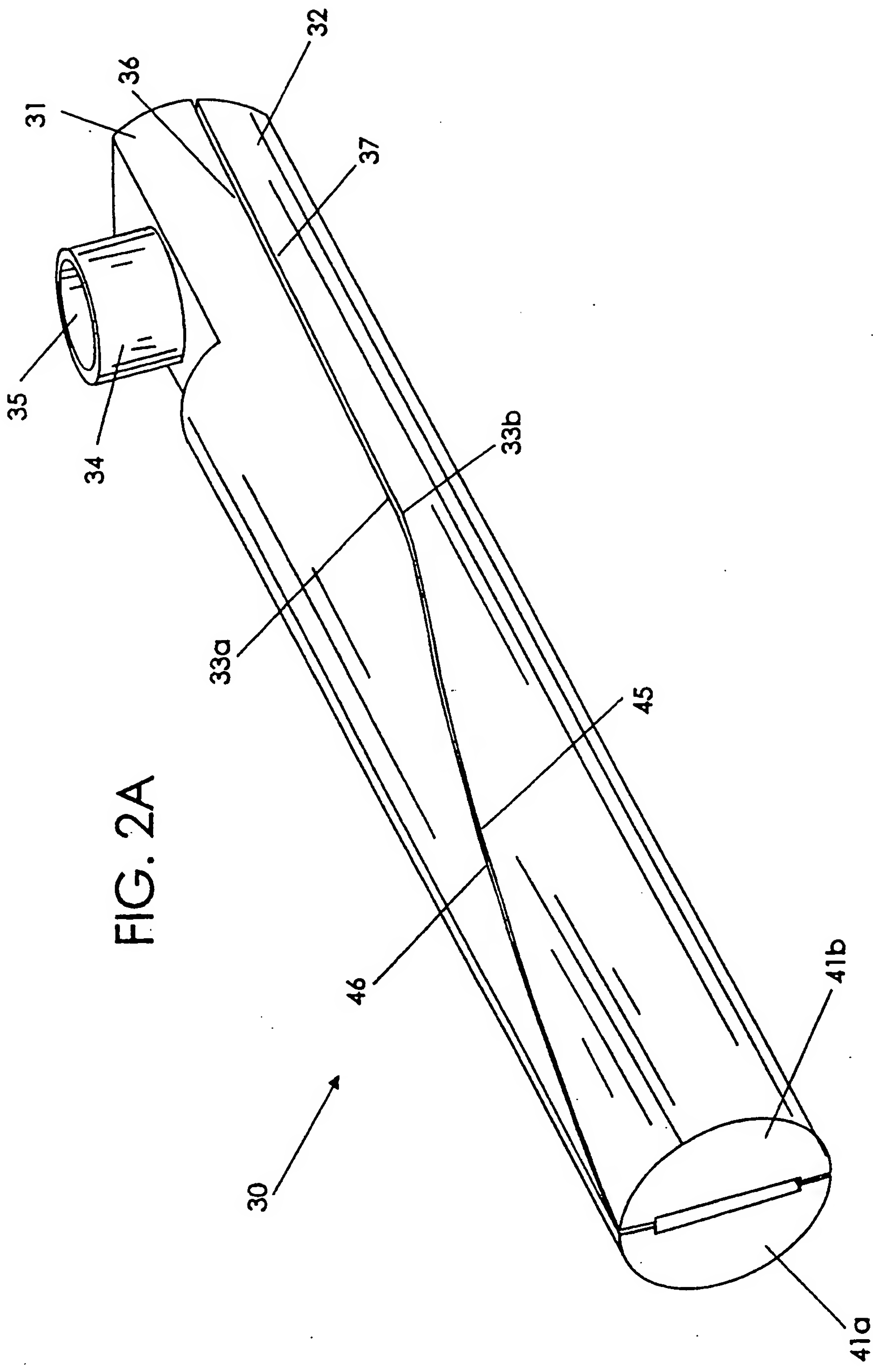


FIG. 2A

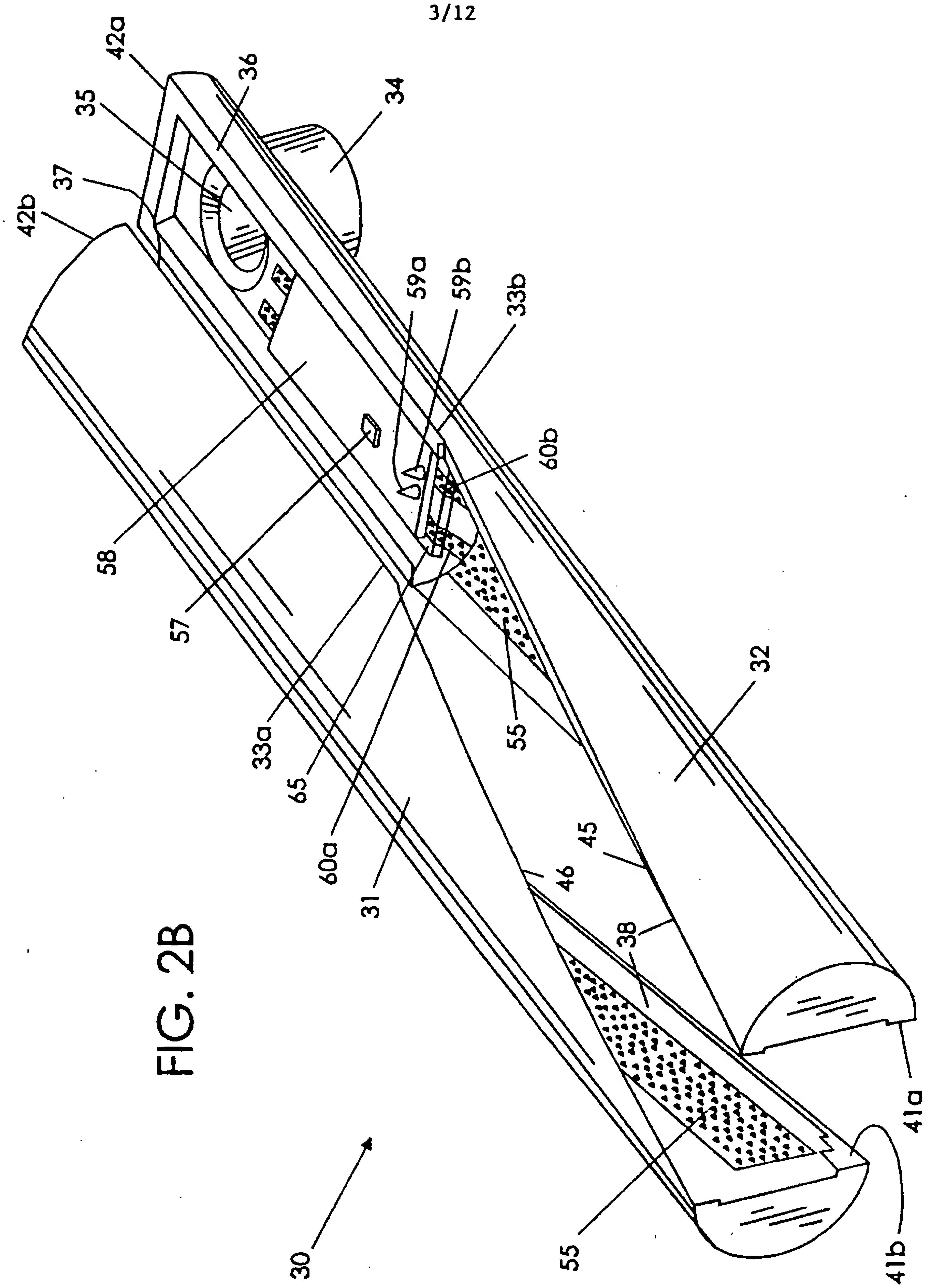

42a
36
34
35
37
42b
59a
59b
33b
60b
58
57
32
55
33a
65
60a
31
45
46
38
41a
55
30
41b

FIG. 2B

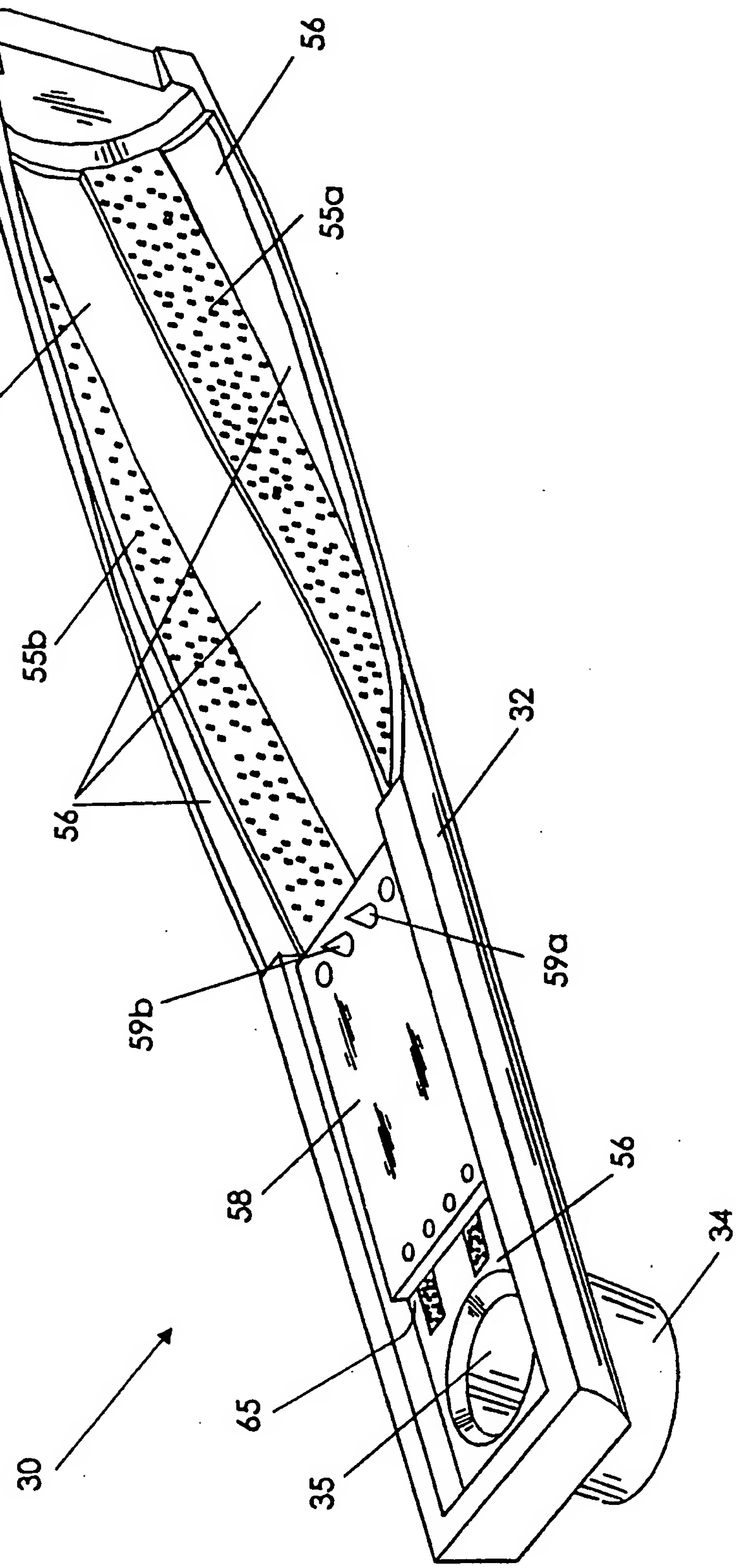


FIG. 3

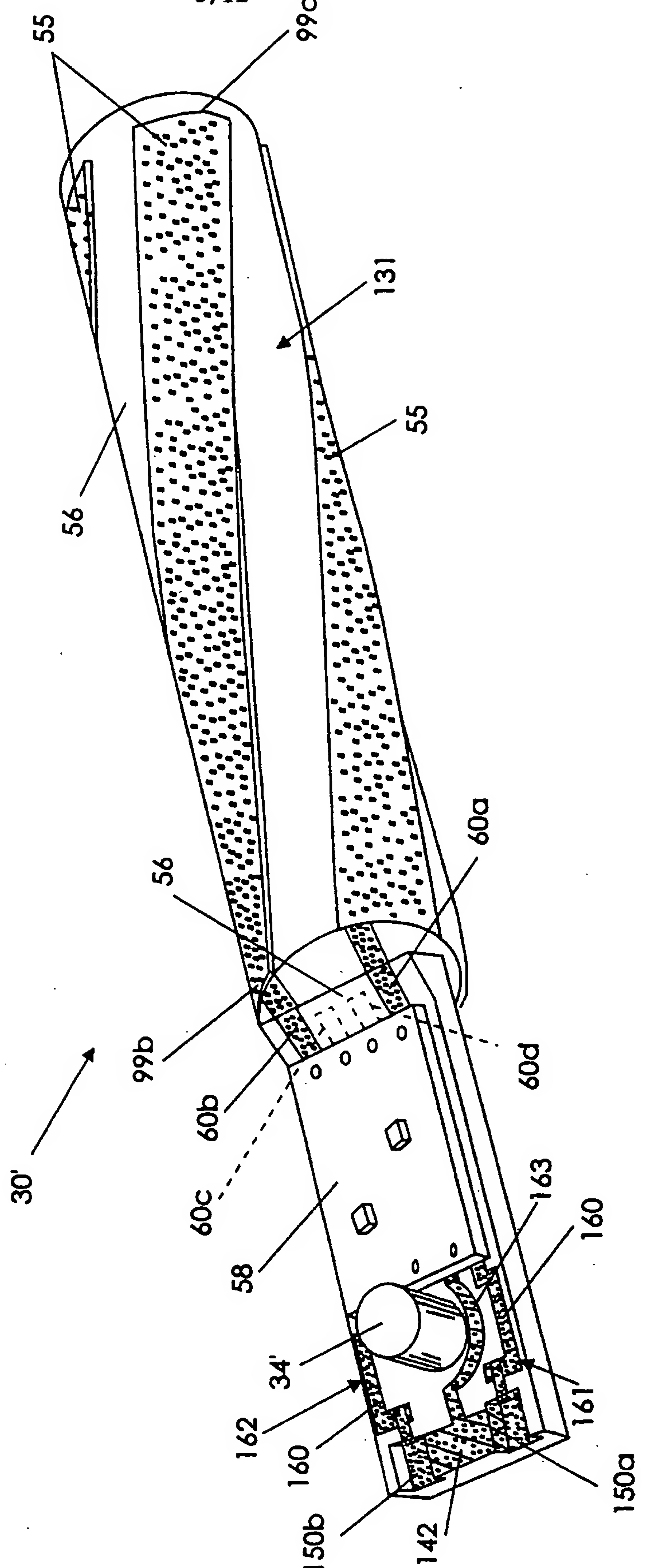

55
99a
131
55
56
60a
56
99b
60d
60b
30'
60c
58
163
160
34'
161
162
160
150a
150b
142

FIG. 4

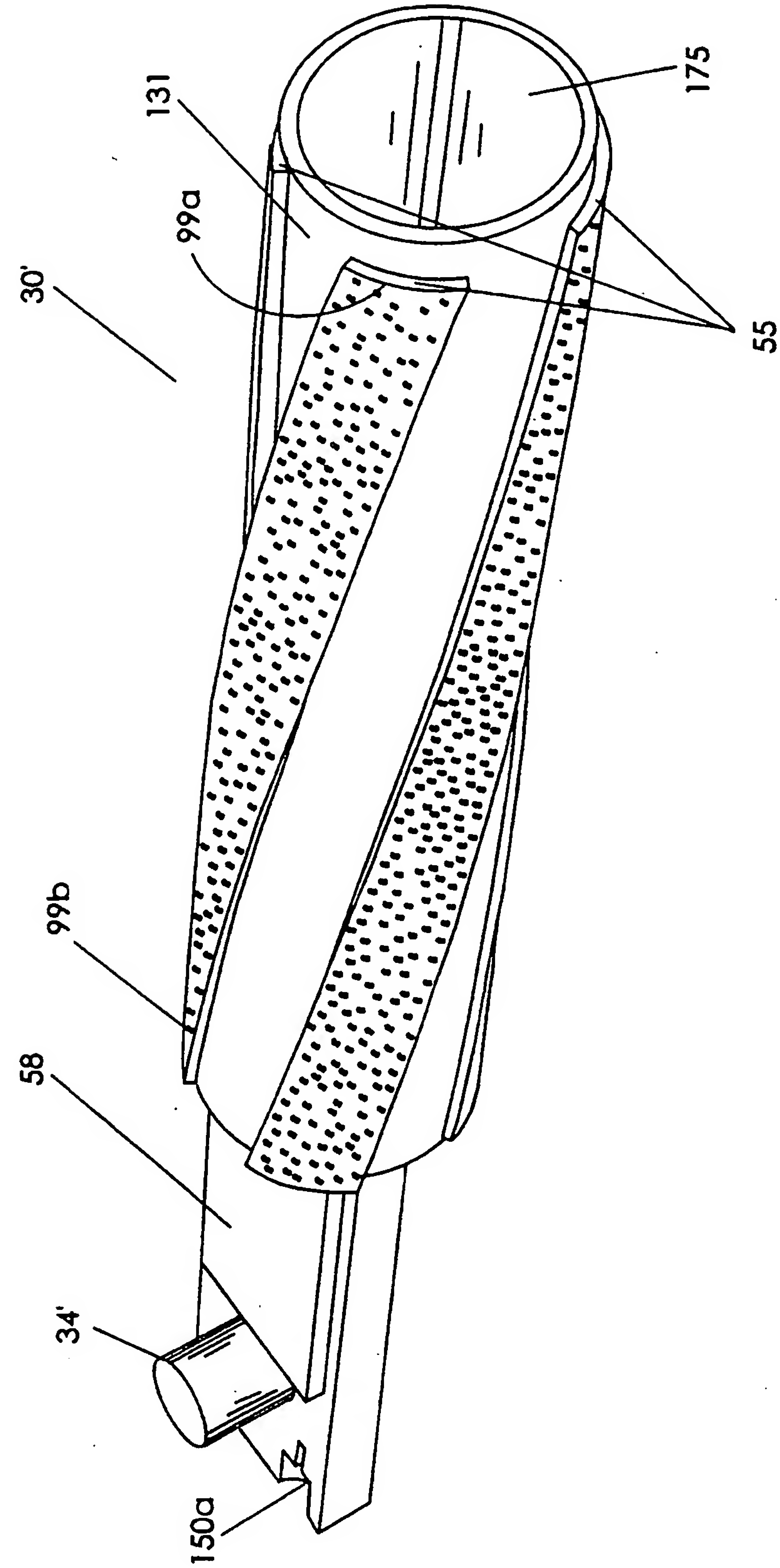


FIG. 5A

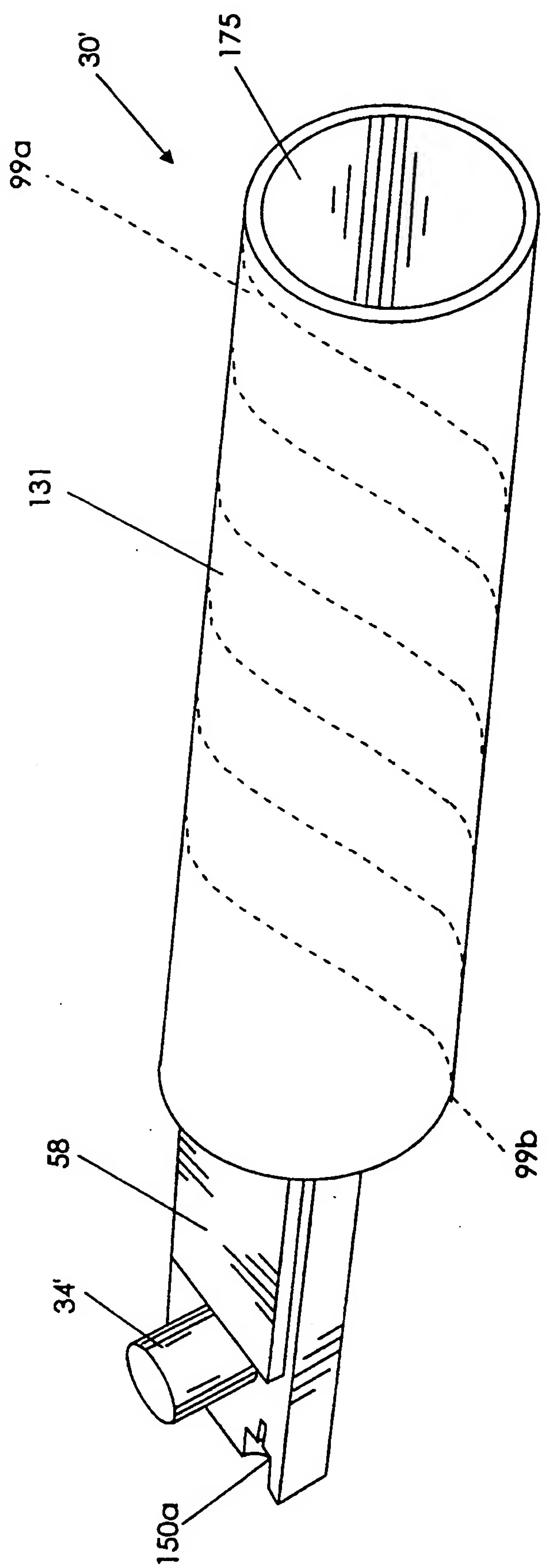


FIG. 5B

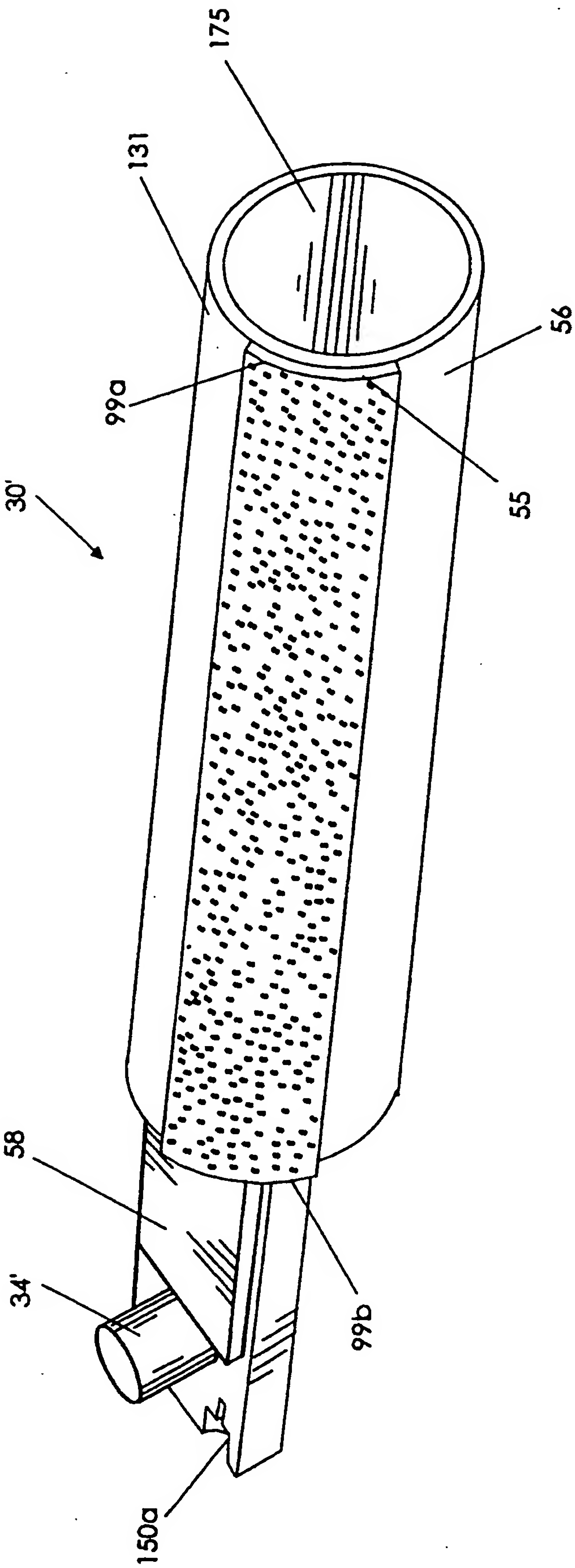


FIG. 5C

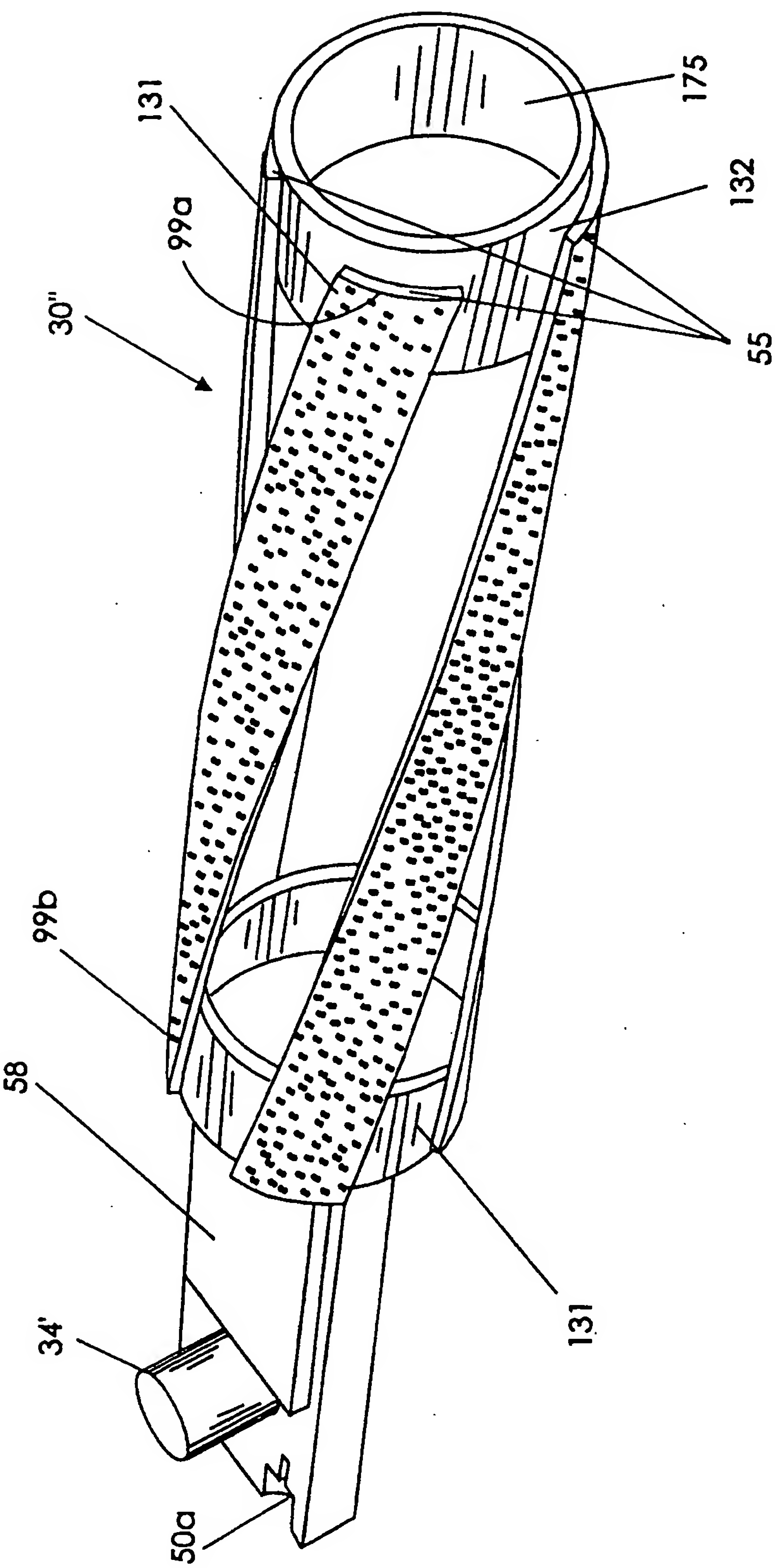


FIG. 5D

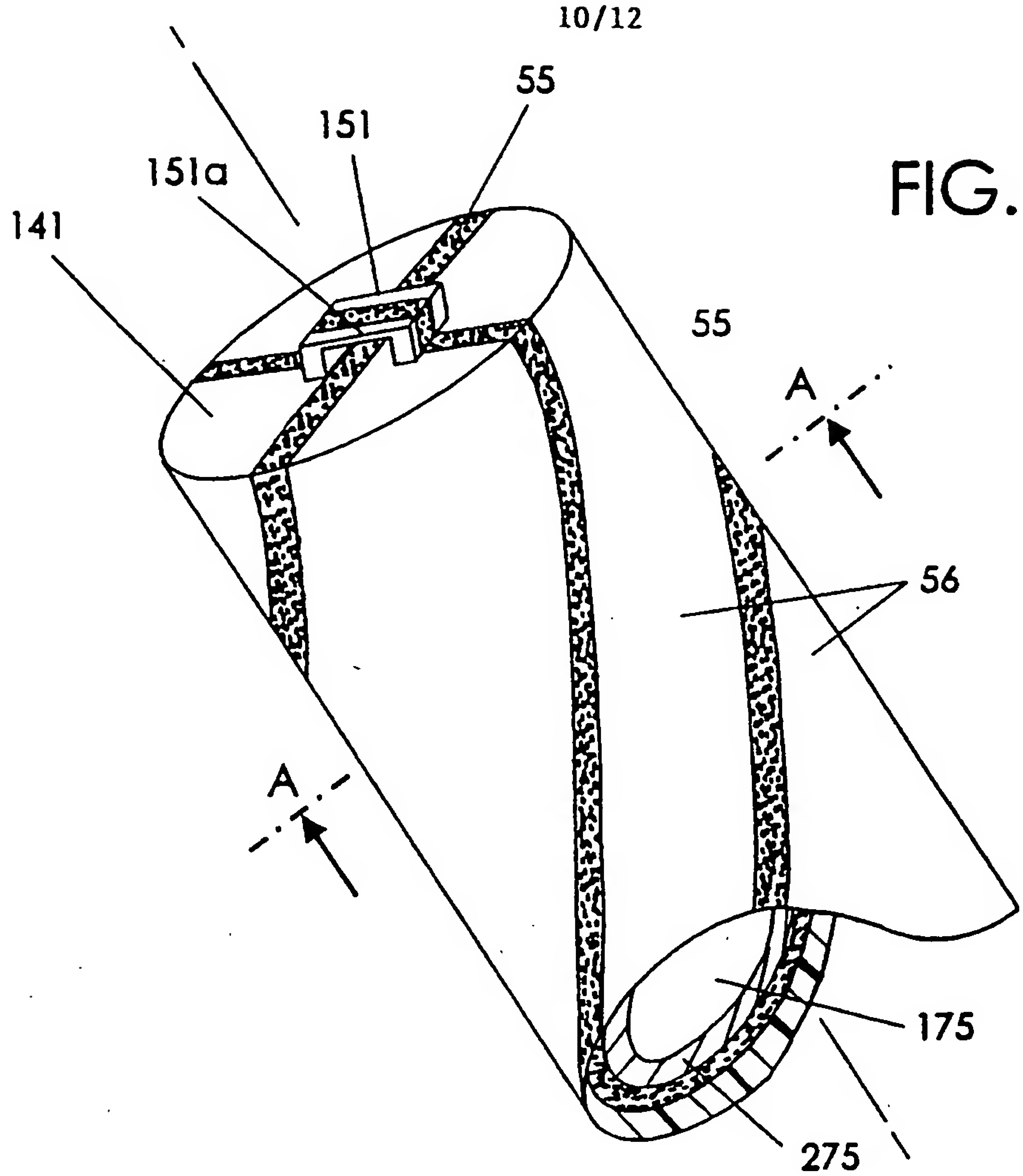


FIG. 6

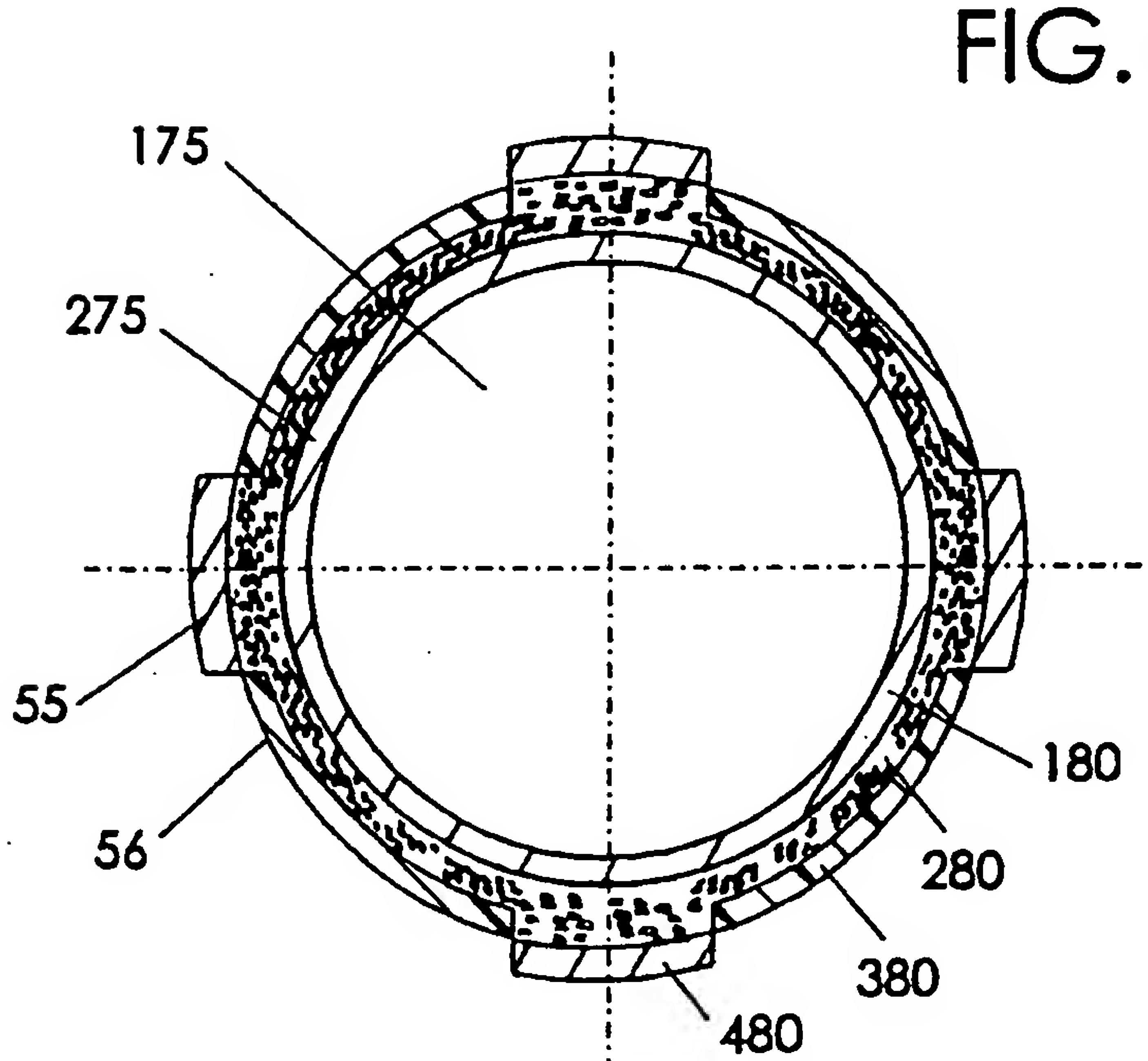


FIG. 6A

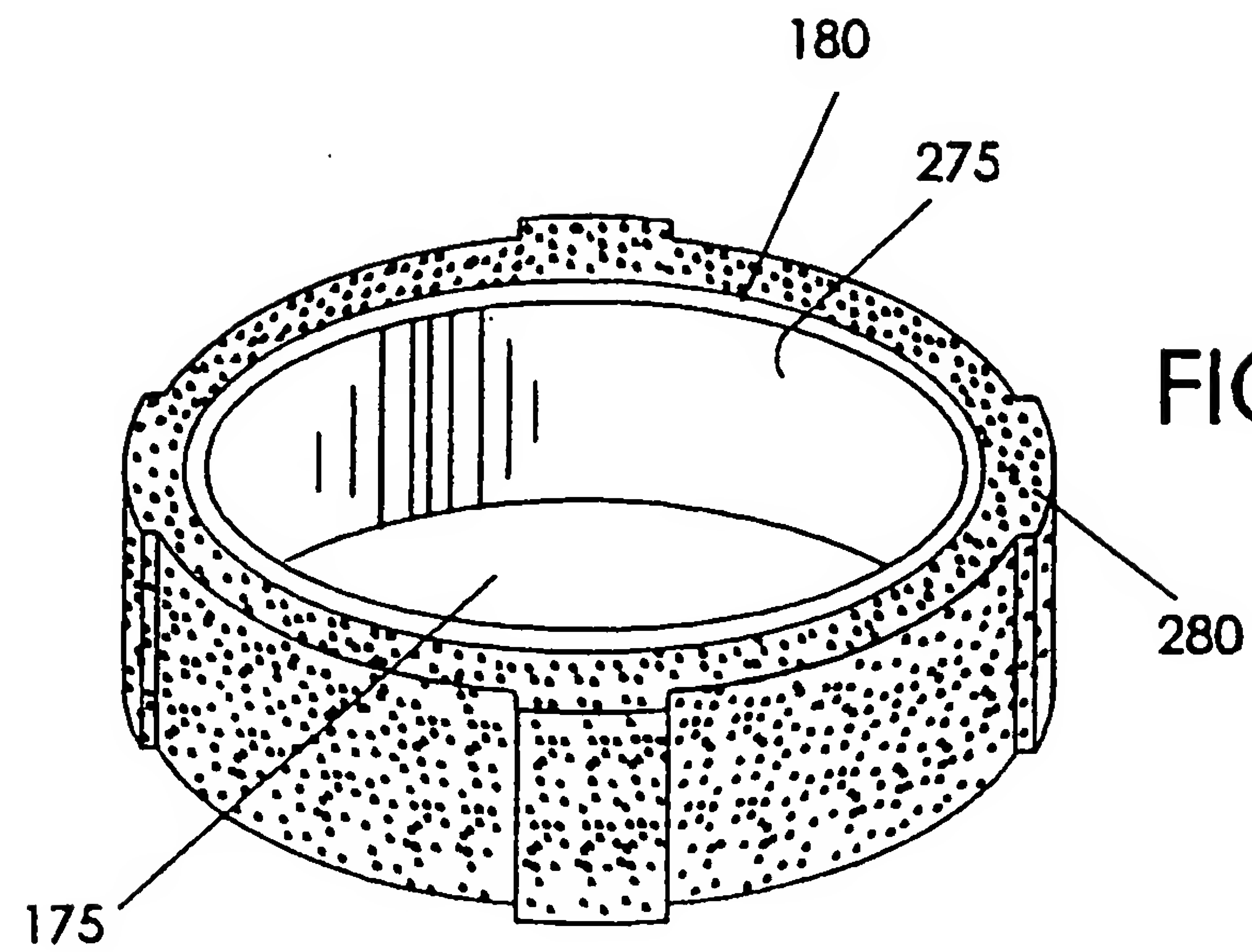


FIG. 7A

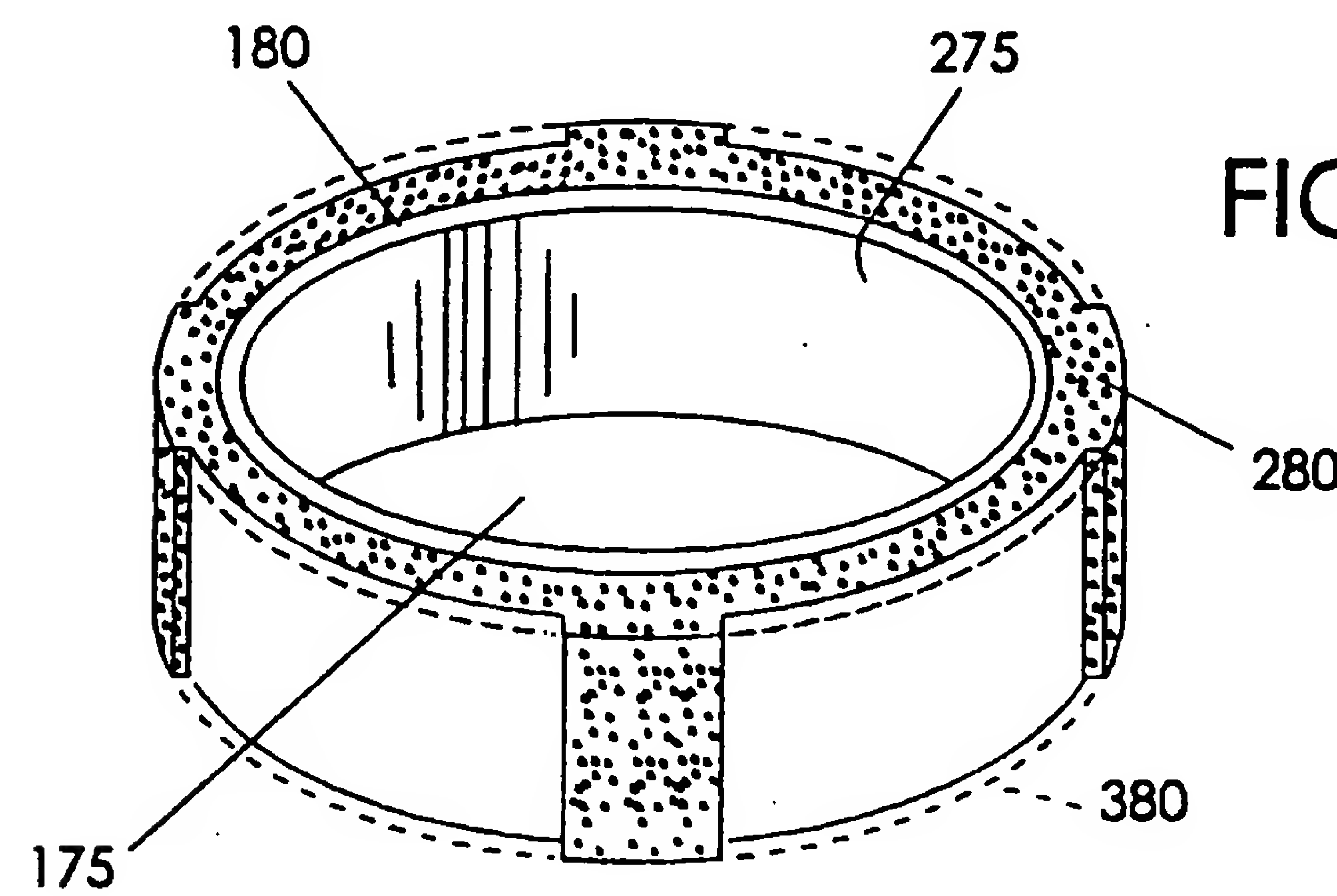


FIG. 7B

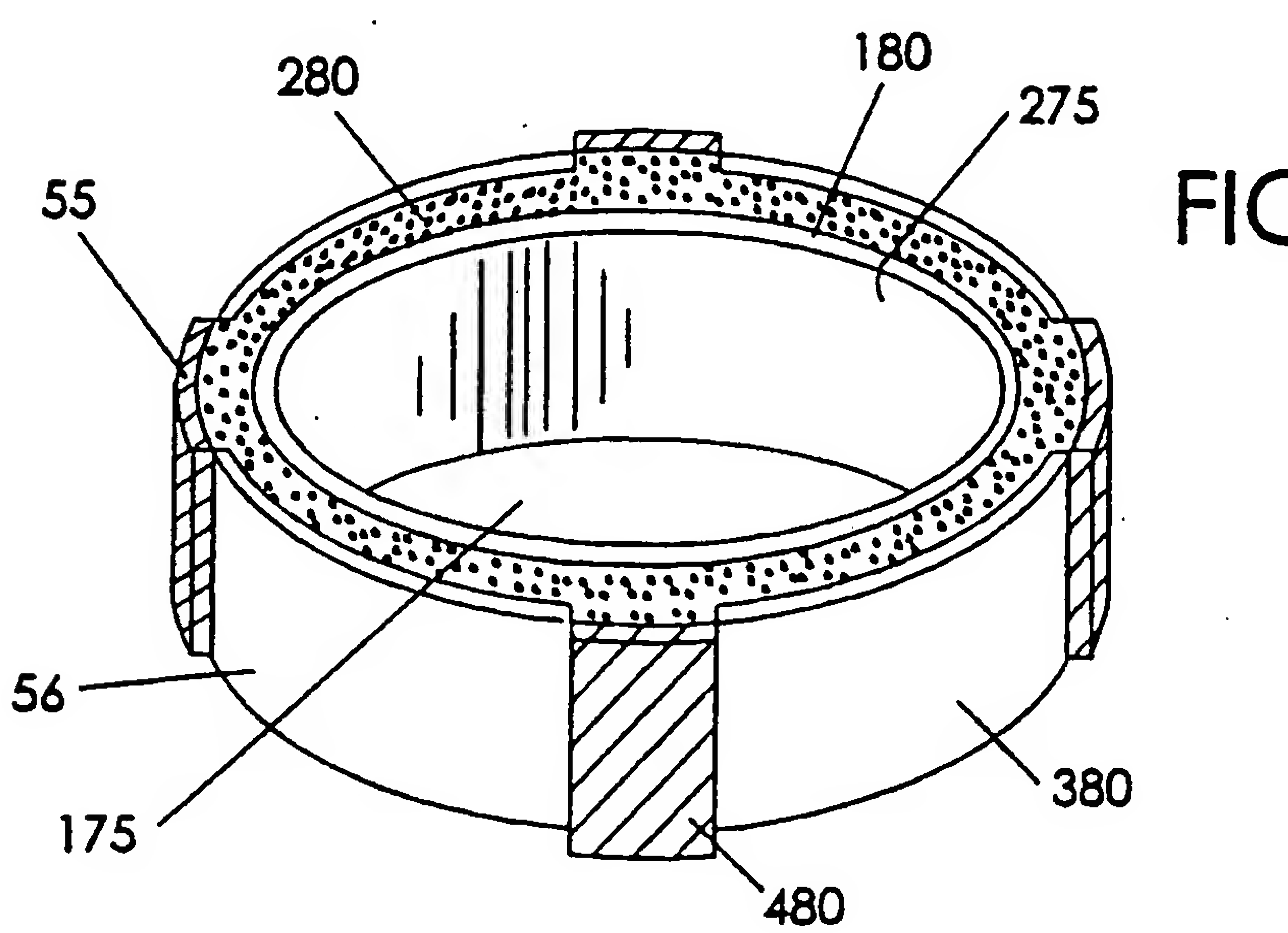


FIG. 7c

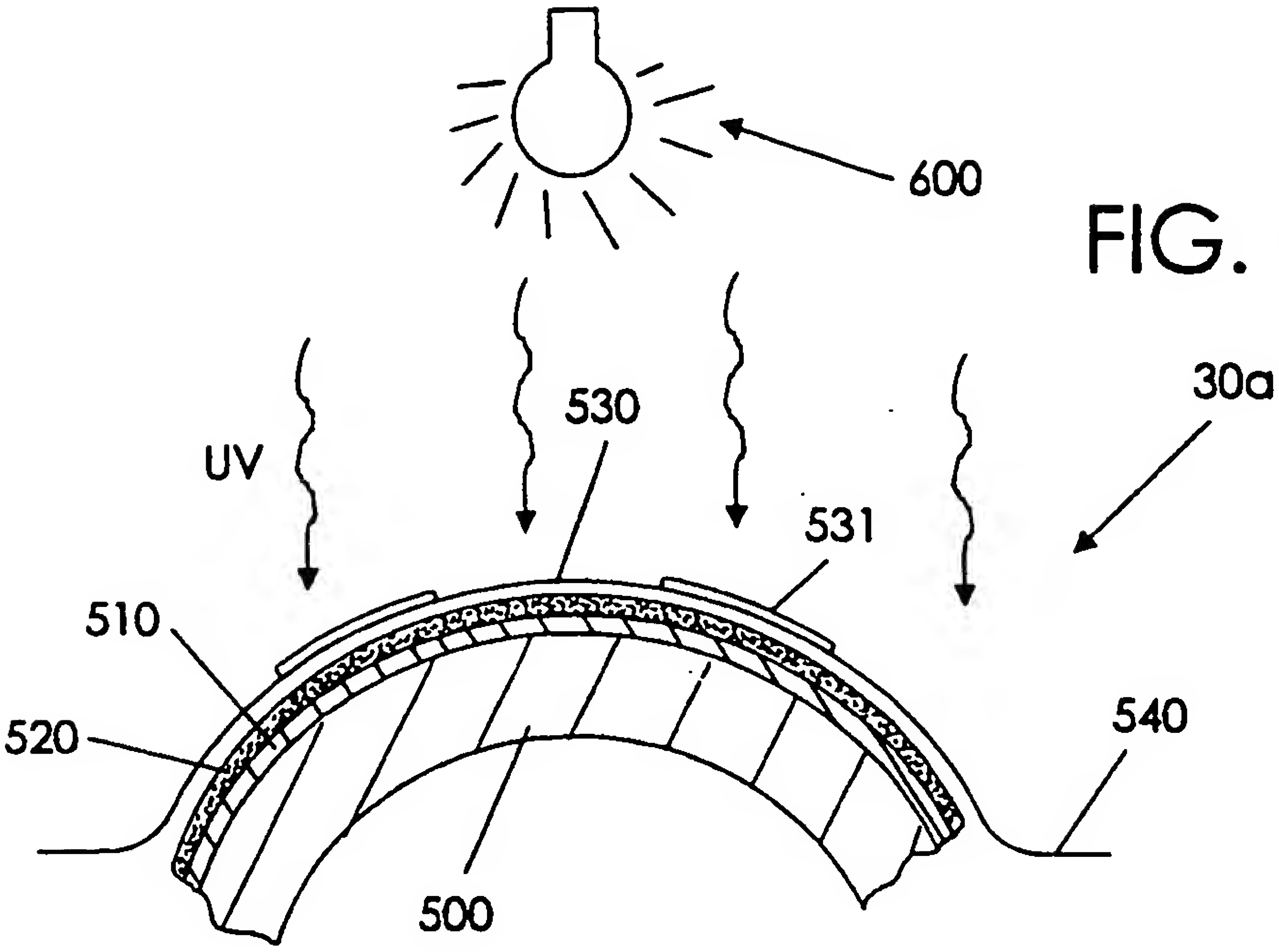


FIG. 8A

FIG. 8B

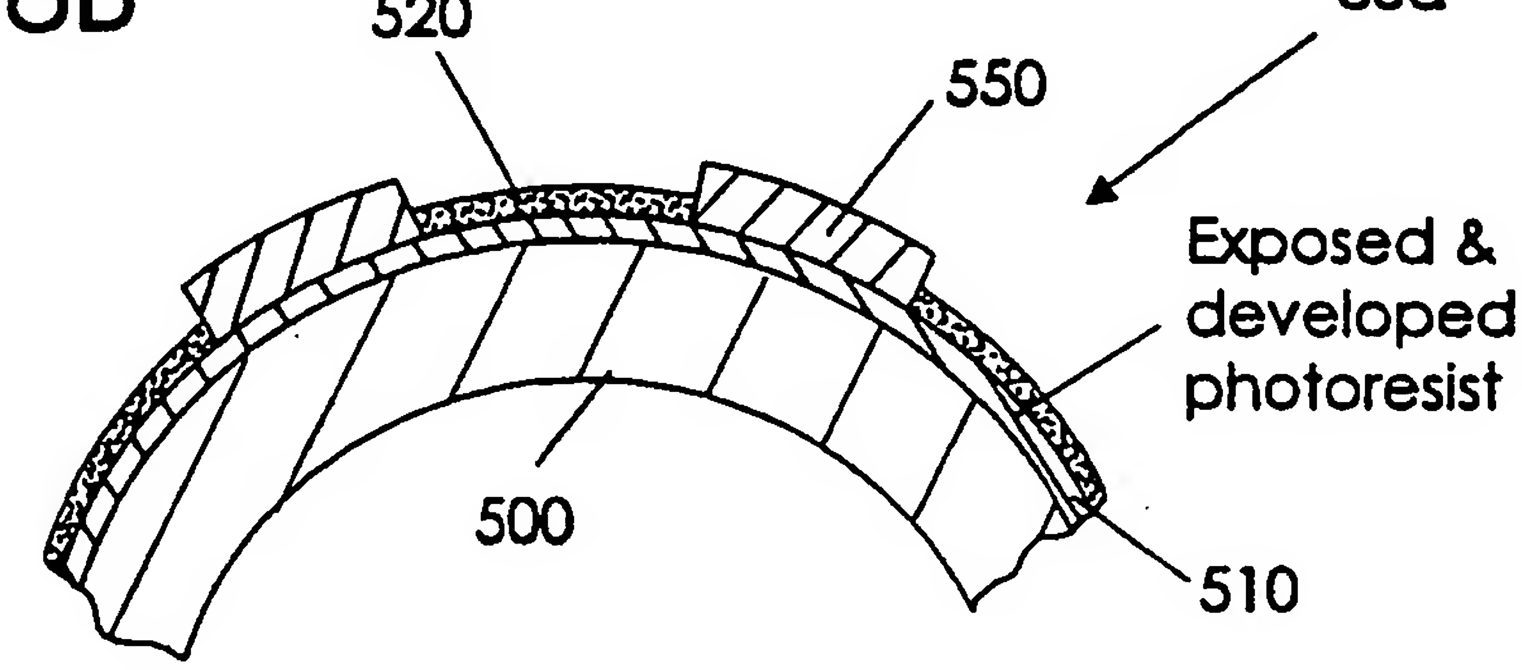
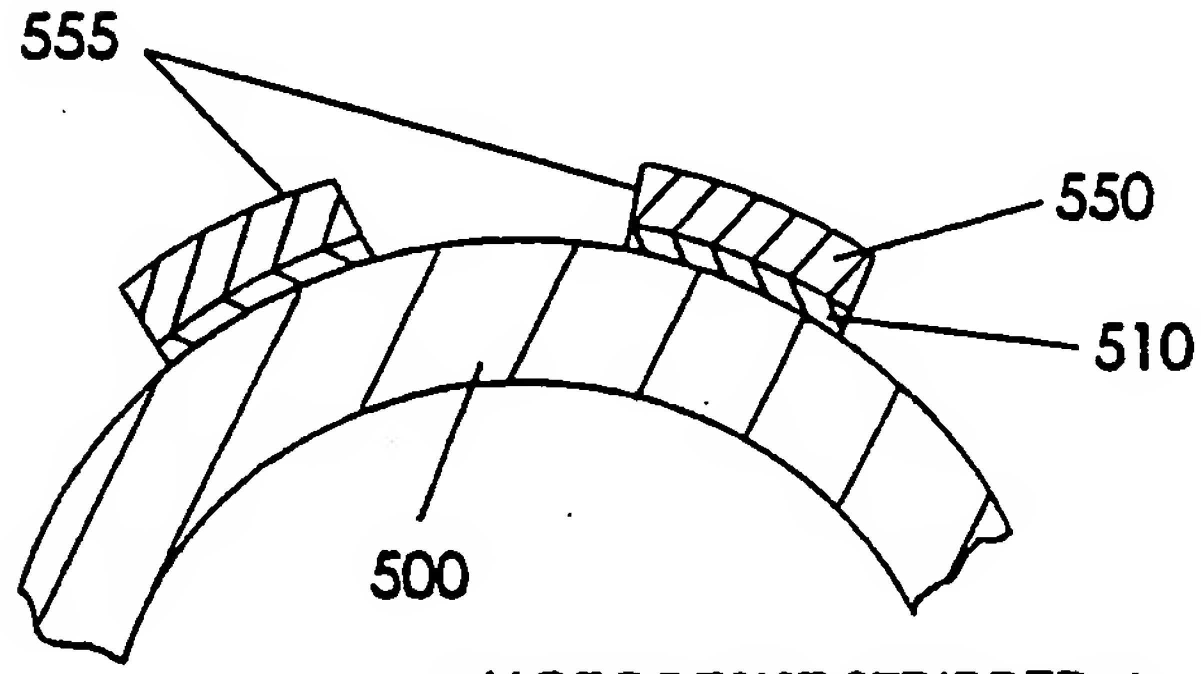


FIG. 8C



pHOTORESIST STRIPPED & BACKGROUND COPPER REMOVED

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H01Q 1/24, 11/08, 1/36

A3

(11) International Publication Number: WO 99/17398

(43) International Publication Date: 8 April 1999 (08.04.99)

(21) International Application Number: PCT/US98/20304

(22) International Filing Date: 29 September 1998 (29.09.98)

(30) Priority Data:
08/939,821 29 September 1997 (29.09.97) US

(71) Applicant: ERICSSON, INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

(72) Inventor: RUDISILL, Charles, A.; 3908 Bamburgh Lane, Apex, NC 27502 (US).

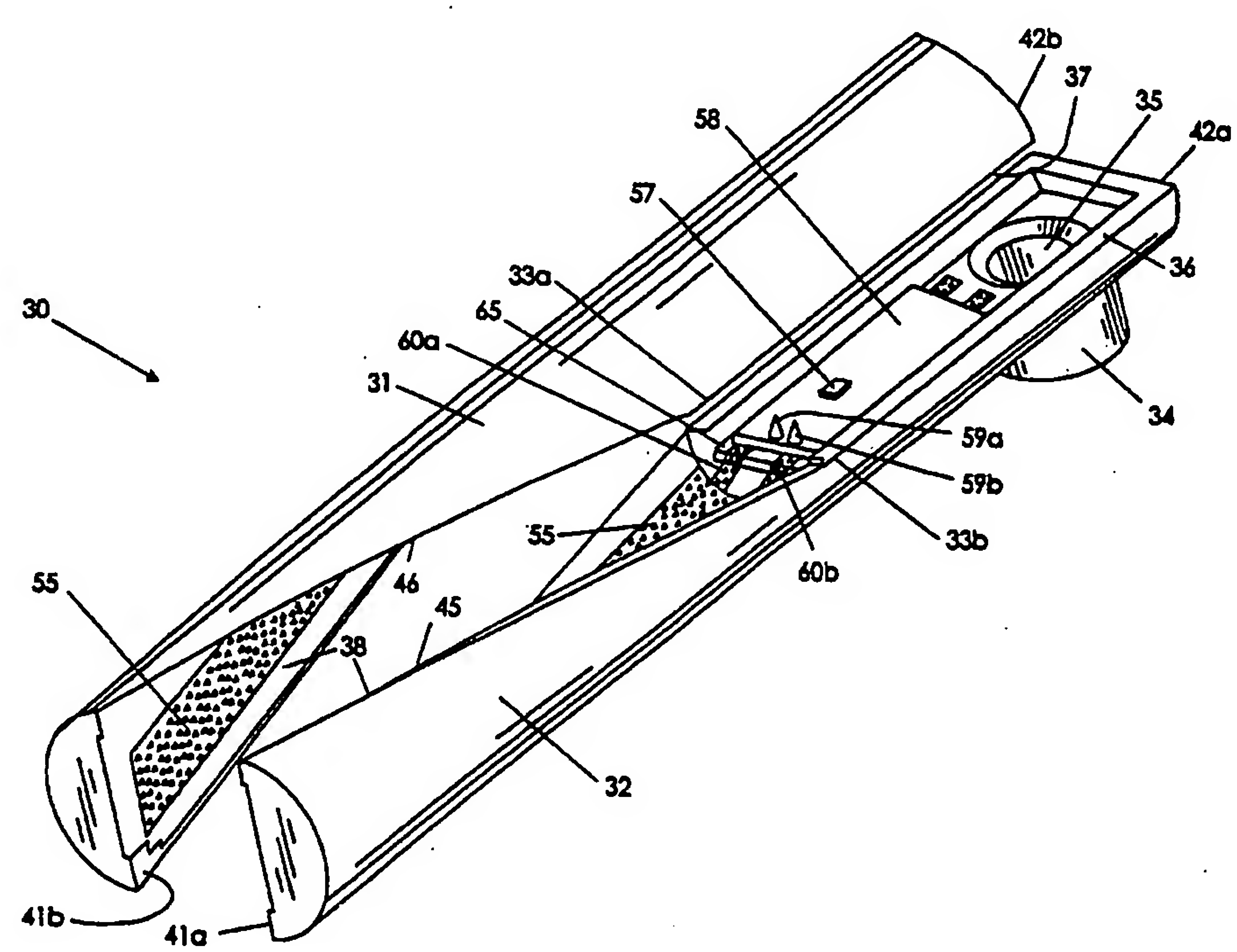
(74) Agents: RICHARDSON, Julie, H. et al.; Myers, Bigel, Sibley, & Sajovec, P.A., P.O. Box 37428, Raleigh, NC 27627 (US).

(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(88) Date of publication of the international search report: 17 June 1999 (17.06.99)

(54) Title: ANTENNAS WITH INTEGRATED WINDINGS



(57) Abstract

Radiotelephone antennas include rigid antenna elements integral to the antenna substrate or housing. As such, the present invention configures the antenna without requiring a separate flex circuit winding to provide the conductive windings in the antenna. Methods for fabrication of the antenna are also described. Preferably, the antenna is formed in a two–shot molding process.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

INTERNATIONAL SEARCH REPORT

Internat'l Application No
PCT/US 98/20304

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01Q1/24 H01Q11/08 H01Q1/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 05602 A (GARMIN INTERNATIONAL INC) 2 April 1992	5-7,9, 13,14, 16-19, 29,30,32
	see page 7, line 3-23; figure 11	
A		1,8,21
A	US 5 403 197 A (ERNST DAVID J ET AL) 4 April 1995 see figure 3	1,5
E	EP 0 889 541 A (TELEDIFFUSION FSE ;FRANCE TELECOM (FR)) 7 January 1999 see column 5, line 53 - column 6, line 40; figure 2	1-3

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 April 1999	07.04.99

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Van Dooren, G

3

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X, L	WO 98 30038 A (KARABINIS PETER D ;MA YAWEI (US); ERICSSON GE MOBILE INC (US); REI) 9 July 1998 L: priority see page 8, line 4 - page 9, line 4; figures 2,3	1-3,5
X	WO 96 06468 A (NAVSTAR SYSTEMS LTD ;LEISTEN OLIVER PAUL (GB)) 29 February 1996 see page 6, line 26 - page 9, column 27; figure 2	20
A		33
X	EP 0 446 656 A (ROGERS CORP) 18 September 1991 see page 2, line 6-18; figures 8-12; example 2	33
Y		34-36,38
X	US 4 853 660 A (SCHLOEMANN ERNST F R A) 1 August 1989 see column 4, line 48 - column 6, line 11; figure 2	33
Y	WO 97 11507 A (QUALCOMM INC) 27 March 1997 see page 6, line 34 - page 9, line 18; figures 1-6	34-36,38
A	WO 96 21955 A (MINNESOTA MINING & MFG) 18 July 1996 see page 5, line 16 - page 7, line 10; figure 1	33

3

INTERNATIONAL SEARCH REPORT	International application No. PCT/US 98/20304

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. claims 1-19,21-32: radome integrated antenna
2. claims 20,33-38: multi-layer antenna

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/20304

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9205602 A	02-04-1992	US 5198831 A	30-03-1993
		AU 8855291 A	15-04-1992
		EP 0550660 A	14-07-1993
		JP 6502286 T	10-03-1994
US 5403197 A	04-04-1995	NONE	
EP 0889541 A	07-01-1999	FR 2765732 A	08-01-1999
WO 9830038 A	09-07-1998	AU 5527198 A	31-07-1998
WO 9606468 A	29-02-1996	AU 3349895 A	14-03-1996
		BR 9508769 A	06-01-1998
		CA 2198375 A	29-02-1996
		EP 0777922 A	11-06-1997
		FI 970759 A	18-03-1997
		GB 2292638 A,B	28-02-1996
		GB 2326532 A,B	23-12-1998
		GB 2326533 A,B	23-12-1998
		JP 10504696 T	06-05-1998
		NO 970832 A	25-04-1997
		PL 319017 A	21-07-1997
		US 5854608 A	29-12-1998
EP 0446656 A	18-09-1991	US 5046238 A	10-09-1991
		DE 69104750 D	01-12-1994
		DE 69104750 T	16-03-1995
		JP 7086748 A	31-03-1995
US 4853660 A	01-08-1989	CA 1291578 A	29-10-1991
WO 9711507 A	27-03-1997	US 5828348 A	27-10-1998
		AU 7368396 A	09-04-1997
		BR 9606654 A	30-09-1997
		CN 1165588 A	19-11-1997
		EP 0793864 A	10-09-1997
		FI 971686 A	23-06-1997
		JP 10509577 T	14-09-1998
WO 9621955 A	18-07-1996	US 5767808 A	16-06-1998
		AU 693640 B	02-07-1998
		AU 4521696 A	31-07-1996
		BR 9510227 A	04-11-1997
		CA 2208688 A	18-07-1996
		EP 0806062 A	12-11-1997
		JP 10512412 T	24-11-1998